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The implications of subsurface CO2 geological storage for mineralogy and geomechanical behavior: Triassic Sherwood Sandstone, East Irish Sea, UK

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There is a growing recognition of the need to reduce the atmospheric concentration of Carbon Dioxide (CO2) to slow the effects of climate change. Many sedimentary basins, which host prolific hydrocarbon resources, are now being reassessed for their potential role as subsurface storage sites, including the East Irish Sea, UK. However, there are implications for subsurface CO2 geological storage, such as mineralogical alterations due to the acidic character of pore fluids and potential changes in pore space and grain character. Such rock-fluid interactions may have consequences for the geomechanical behavior and petrophysical parameters.
In this study, we undertake an integrated method through hydrothermal and mechanical experiments to assess the impacts of CO2 storage by comparing the pre- and post-reacted samples in terms of mineralogy, petrophysical parameters and geomechanical behavior of Triassic sandstone core from the Sherwood Sandstone Group, South Morecambe Field, (110/8a-C5) East Irish Sea, UK. The Triassic Core samples are subarkosic arenites made up mainly of quartz, K-feldspar, dolomite and illite which are determined using optical microscopy, SEM and XRD. Detailed SEM images and SEM-EDX mapping illustrate dolomite cement, partial alteration of K-feldspars and illite coating the quartz grains, which was largely responsible for porosity preservation. The density and porosity of the pre-reacted samples are 2.1g/cc and ~15 - 20.5% respectively. The confined permeability is 1.9e-19m2. In terms of the rock's geomechanical behavior, the Young's Modulus obtained after the triaxial loading test is 5.3GPa. Hydrothermal reactor experiments were carried out in a cylindrical stainless steel Parker Autoclave Engineers with 500 ml volume, the vessel was heated by a ceramic band heater at 80°C and the pressure was raised and kept constant at 20 MPa. In each experiment, the vessel was partially filled with a seawater-like fluid, the Triassic sandstone core was immersed in this fluid, CO2 was injected into the remaining space and the autoclave was pressurized. The remaining fluid was analysed for key chemical species using ICP-OES to help the understand mineralogical alterations and potential authigenesis.
Carbonate dissolution, increase of the alteration degree of K-feldspar, subordinate Illite precipitation or even dissolution in the hydrothermal reacted sample can be expected leading to the modification of pore space and rock cohesion. Considering that mineral dissolution is the main rock alteration process, an increase in porosity and permeability can be expected. Conversely, the density and Young's Modulus can have smaller values mainly due to the loss of dolomite cement and consequent rock weakening.
Investigating the potential physical changes in porosity, permeability and rock strength and comparison of the results from pre- and post-experiments, is crucial to assess which are the main reactive minerals and classify the best and safest rock facies for a subsurface CO2 geological storage. The results presented will be used to predict the best petrophysical facies and improve our understanding of injecting CO2 to avoid fractures and fault reactivation.

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